



Pushing the Governance Boundaries: Making Transparent the Role of Water Utilities in Managing Urban Waterways

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Abstract Integrated Water Resource Management (IWRM) requires simultaneous consideration of the multiple benefits that attend water. IWRM can also be more challenging in regulatory environments where the resource manager must justify choices and elements of each intervention. This is particularly challenging in the context of urban waterways that have many uses including an ecological function and a source of human amenity. To justify expenditure on maintaining and improving urban waterways for ecological and/or amenity changes regulated utilities must be able to articulate and measure these types of values with at least some degree of precision. This paper presents a generic and systematic framework for understanding the ecological and amenity values of urban waterways. We illustrate deployment of the framework in the case of Melbourne, one of Australia's fastest growing cities and a location ranked as amongst the most liveable since 2011. We also explore how the results could improve the way we measure benefits in dollar terms.

Keywords Integrated water resources management (IWRM) · Ecological value · Amenity value · Waterways · Delphi analysis

1 Introduction

Water pricing, regulation and management remain contentious worldwide (see, for instance, Gareau and Crow 2006). The sources of controversy include the perception that water is especially unique and requires alternative institutional arrangements to deal with hydraulic and social nuances; the notion that water is 'gifted' from nature and cannot be effectively priced or controlled to reflect scarcity; political costs associated with reassigning rights that were

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historically given to users without cost; recognition that water governance is at least as important as water engineering; and increased awareness that the fugitive nature of the resource makes it difficult to optimise uses across multiple demands, including environmental claims.

These issues have manifested in a number of competing approaches to water management. On the one hand, numerous analysts have urged governments to adopt a strict ‘user-pay’ principle to avoid excessive resource exploitation (see, for example, ICWE 1992; United Nations 1992). On the other hand, observers have noted that water provides a range of non-marketable services, such that identifying ‘users’ is problematic enough, let alone assigning a price to reflect the benefits they enjoy (see, for instance, Raymond et al. 2008; Lamoree and van Steenberg 2006; Savenije and van der Zaag 2002). It is against that background that the concept of Integrated Water Resources Management (IWRM) has gained prominence.

IWRM is commonly defined as “a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (Global Water Partnership – Technical Advisory Committee (GWP-TAC) 2000, p. xiv). Thomas and Durham (2003, p. 24) have defined the notion as “a sustainable approach to water management that recognizes its multidimensional character – time, space, multidiscipline and stakeholders – and the necessity to address, embrace and relate these dimensions holistically so that sustainable solutions can be brought about.” IWRM has several core tenets but a key issue is the treatment of water planning at a catchment scale. The logic of this approach is that upstream choices have downstream consequences so managing water holistically offers more scope for dealing with externalities or spill-over effects. Notwithstanding its compelling logic IWRM is not without its critics. More specifically, Molle (2008) notes that IWRM can often disguise the competing nature of some objectives and the mechanisms for resolving trade-offs is not always clear. Similarly, Biswas (2004) observes that a range of interventions can easily be passed off as IWRM and Walther (1987) argues that the concept is inclined to produce ‘black box’ solutions.

IWRM has nonetheless become a cornerstone for water planning in many countries and in various settings. In Europe, IWRM has been embedded in proclamations related to the European Water Framework Directive (2000) but its implementation can be complicated by cross-jurisdictional waterways and competing national demands (e.g. European Commission 2000). IWRM can also occur in rural contexts, where the primary users are agricultural and environmental interests, and in urban settings. In the case of the latter pressures can come from industrial and potable demands, but increasing environmental and amenity demands also attend urban water management, especially in richer nations where amenity and environmental goods are increasingly demanded.

Whilst most of these principles are well-understood by policy makers and analysts, the contradictions that they embed are often not revealed until attempts are made to operationalise them. For example, IWRM implies that multiple uses must be considered holistically, but how is that approach reconciled with the need for clear specification of individual beneficiaries and the costs they should meet, especially when some elements of water have public good qualities?

Lamoree and van Steenberg (2006, p. 100) highlight these challenges to answering these types of questions “Through investment and management interventions, values are created (or destroyed) in connection to these functions: productivity values, amenity values, property values, environmental conservation values, and more. The challenge in IWRM is to, at a minimum, balance these different functions and values, yet preferably to optimize them.” The difficulty of striking a balance and optimising management is especially evident in the case of

urban waterways used for amenity and environmental outcomes. At a broad level urban waterways have an ecological function but can also be a source of human amenity. First, urban waterways can provide habitat for indigenous plants and animals or, as a minimum, provide passage for important species between ecologically significant sites. Second, waterways can provide a sense of ‘enjoyment’ for those nearby, irrespective of ecological status (see, for example, Veldarde et al. 2007; Völker and Kistemann 2011). An ongoing challenge however is identifying ways of incorporating these notions into current regulations and institutional approaches to water management.

Adding to this complexity is the requirement to understand values a priori. Only by knowing values ‘in advance’ can the manager hope to choose optimal IWRM strategies that ultimately change some functional element of waterways. A precursor to improving our understanding of these changes is understanding the drivers of key values. In this paper, we address this by unpacking the drivers of amenity and ecological value of urban waterways to better inform how trade-offs might be made.

More specifically, this paper uses the case of urban water management in Melbourne to highlight an approach that can be used to deal with the dual tasks of managing water in an integrated fashion while retaining transparency about the benefits and costs of specific interventions.

Melbourne has been chosen specifically as it is one of Australia’s fastest growing cities with the population estimated to increase by 60 % by 2050, reaching 6.5 million (OLV 2013). Growth of this magnitude substantially raises the stakes on current management of urban waterways for amenity and ecological benefit and without a clear framework for analysis the risks of irreversible and poor choices are substantial. In addition, Melbourne has been consistently rated amongst the world’s most liveable cities since 2011 (Economist Intelligence Group 2013) offering a unique opportunity to explore policy choices in a setting where findings will gain immediate traction and where lessons are likely to be readily considered by other jurisdictions.

Melbourne also has other benefits as a case study for this analysis inasmuch as some empirical work already exists in the context of unpacking ecological and amenity values. First, the Victorian Index of Stream Condition (ISC) provides an indication of the ecological health of Melbourne’s waterways. The ISC is made up of five sub-indices: hydrology, streamside zone, physical form, water quality and aquatic life. Each river reach assessed is given an overall ISC score of between 0 and 50. Accordingly, 36 % of Melbourne’s waterways are considered to have high ecological values i.e. have been given an ISC score of 30 or above. Second, in terms of the existing amenity provided by Melbourne’s waterways, Melbourne Waters *Healthy Waterway Strategy* (2013) has identified amenity priority areas within management units/streams based on visitation, popularity and satisfaction of the public. Accordingly, 41 % of Melbourne’s waterways have been categorized as having high amenity thus adjudged as priority areas by Melbourne Water.

In Melbourne, waterways that pass through the city are managed by the water utility that provides bulk potable water supplies to the metropolis and the same entity administers wastewater treatment. The entity is known as Melbourne Water Corporation and is owned by the state government but managed along corporate lines. Prima facie this should lead to a degree of IWRM that might not occur were the various water management responsibilities are disbursed across a range of institutions.

In order to satisfy economic regulators that all of the utility’s services are provided at lowest cost, Melbourne Water Corporation is required to prepare 5-year plans that show the demand for its various activities, including those relating to amenity and ecological functioning or

waterways. Finding a way to do this has proven challenging, but the lessons offered here stand to guide others in the more general search for efficient and innovative solutions to integrated water management.

In this paper we present a theoretical framework that was developed by systematically tapping expert knowledge about the ecological and amenity value of urban waterways. We use the framework and the results from a Delphi analysis to explore techniques for valuing different management actions. In addition we contemplate the implications for institutional arrangements that can accommodate IWRM and the need for transparent regulation.

The paper itself comprises five additional parts. In Section 2 a brief synopsis of the institutional arrangements that circumscribe water management in Melbourne and Victoria, Australia, is offered. This section also provides the context for the analysis of amenity and ecological water values. Section 3 presents a methodological approach for articulating hard-to-measure constructs like ecological and amenity benefits. The results from the application of this Delphi method are presented in Section 4 before the implications for efficient regulation are considered in Section 5. The final section comprises brief concluding remarks.

2 Institutional Arrangements for Urban Water Management

IWRM has become an integral part of the water planning philosophies in all Australian jurisdictions. Australian water resources are principally controlled by state governments and each has sought to develop plans, regulations and policies consistent with the National Water Initiative (NWI) agreed in 2004. The NWI established a blueprint whereby water was recognised as an economic good; water pricing was to be introduced to reflect costs; water rights were clarified, separated from land and made tradeable; and water regulation separated from service delivery. Economic regulation has subsequently been introduced in most states, where utilities must demonstrate to regulators the value of services delivered and that demands are being met at lowest possible costs.

Australia's institutions for managing water have been praised by international observers and scholars alike (e.g. The Economist 2003) such that actions in Australia can have significant ramifications for international water management strategies. One of the major accomplishments of water management in Australia was the introduction of cost-reflective pricing as part of the National Water Initiative of 2004 and earlier reforms. This approach has now been broadly adopted in urban areas and was again ratified by the National Resource Management Ministerial Council in 2010 (Crase et al. 2015).

In Australia, regulated utilities must be able to articulate and measure different values with some degree of precision. Utilities must meet regulators' calls for lowest-cost expenditures and yet also deal with insurances at the policy level that water be managed holistically for the betterment of the community. But what is often overlooked in this setting is the need to understand the potential trade-offs that are made between different water management objectives, or to appreciate potential synergies between water management goals. For example, in the case of urban water management, there are potential trade-offs between increasing the ecologically value of waterways at the expense of amenity value (and vice versa). But what are the amenity and ecological values of urban waterways and, importantly, what are the most robust mechanisms for articulating those values? Without answering these types of questions it is not possible to both effectively employ IWRM and to also meet the needs of regulators that costs related to various services be made transparent.

As noted earlier, the responsibility of water management in Australia's states and territories lies with numerous government agencies and water corporations. For instance, in the state of Victoria the Department of Environment, Land, Water and Planning (DELWP) has responsibility for managing the state's water resources in partnership with the Victorian water corporations. In the metropolitan area of Victoria, Melbourne Water Corporation (Melbourne Water) has responsibility for bulk water supply and bulk sewerage services. Melbourne Water is owned by the State government and since 2004 has also been the main caretaker of river health in and near Melbourne. Melbourne Water is also responsible for regional drainage, waterways and floodplain management for the region. Retail water and sewerage services in the metropolitan area are provided by three corporations; namely, South East Water, Yarra Valley Water and City West Water. There are 13 additional regional water corporations which operate outside the metropolitan area, many controlling their own bulk water supplies (Crase et al. 2015). Melbourne Water and all of the urban water corporations are subject to economic regulation and are required to have 5-year Water Plans approved by the Essential Services Commission (ESC). In terms of the environmental performance of the urban water corporations, the Environmental Protection Agency Victoria monitors and oversees Victoria's water sector. The oversight of the sector's financial management standards lies with the Department of Treasury and Finance (DTF).

As noted earlier, a key institutional principle for water utilities is transparency and an associated requirement to be able to rationalise expenditures as legislated monopolies. This includes clarity around expenditures on urban waterways. Achieving transparency is not always straight forward, especially when some relationships between actions and values requires specialised knowledge.

3 Using Delphi to Gain Insights to Measurement Dilemmas

In Greek mythology the 'oracle of Delphi' was able to provide the answers or the 'truth' to vexed questions. Experts in the topic of interest are used in modern day Delphi research to provide answers to vexed questions (Hasson et al. 2000). The Delphi approach consists of several rounds of open ended responses and/or brief surveys that are presented to a panel of experts who anonymously provide input. The first round initially generates ideas and information from the experts about the topic. This content is then summarised by the researchers and then re-presented to the experts for approval, modification or extension but with the aim of obtaining consensus. The process can be repeated over a number of 'rounds' and concludes when consensus is reached (De Villiers et al. 2005). Thus, a Delphi study comprises a structured process whereby knowledge dispersed across a group is collected and condensed, usually via several rounds of interaction with experts (Maybery et al. 2009).

The Delphi technique has been employed successfully in a broad range of areas including curriculum development for health sciences education (De Villiers et al. 2005), HR research (Hatcher and Colton 2007), and designing a mental health training package (Whitman et al. 2009). The Delphi technique has also been used to assist with environmental decision-making and environmental monitoring program design (Richey et al. 1985).

In addition, the Delphi technique is often employed to enable experts in the field to more clearly define concepts that are ambiguous (see, for instance, Raine 2006). In this case, the technique has a lot to offer around clarifying concepts such as ecological value and amenity value. For instance, in the case of urban waterway management, the term 'amenity' is

frequently used by water agencies as a catch-all for human values that are not directly associated with ecological characteristics but this is no easy thing to measure; the attributes that characterise high amenity in one location might do a poor job in another (e.g. Horwitz and Carter 2011). Therefore, analysis using the Delphi approach will increase our understanding of the key drivers and components of these concepts.

Accordingly, this study used a Delphi to systematically tap expertise about the ecological and amenity value of urban waterways. In this instance, experts in the ecology and amenity of waterways were subjected to three rounds of collection and synthesis using an on-line instrument.

The Delphi results aimed to deliver expert consensus on the classification of different waterway benefits along three dimensions: drivers, components and outcomes. These three dimensions are hierarchical and enable us to distinguish between the tangible and higher-order characteristics of amenity and ecological values. For instance, in the case of amenity, the drivers are highlighted as the natural or physical qualities/characteristics of the waterways; components are the aesthetic attributes or characteristics (e.g. escape, appeal, recreation); and the outcome is personal well-being. In the case of ecological value, drivers are the measurable characteristics that have a causal relationship with the components and the final outcome is ecological well-being.

One advantage of this approach is that any descriptors developed about ecological and amenity value would be simultaneously traceable to existing standards or indices thus ensuring they are relevant and practical for management options. Essentially, the Delphi analysis used here should enable the formation of more accurate information surrounding amenity and ecological values of Melbourne's waterways, which can then be distributed to other key stakeholders (e.g. policy makers, managers, consumers) to better inform their decision-making. For example, the linkages uncovered here could be used to clarify how values are created or destroyed by particular choices.

4 Results

4.1 Recruitment

4.1.1 *Selection of Participants*

Critical to the Delphi methodology is the selection of experts as participants. In the initial stages a steering committee was developed to support and guide this and other components of the wider research project. The steering group included key stakeholders from the water sector and in conjunction with the research team a definition of 'experts' was developed. For the purpose of this study an expert in the amenity of Melbourne's waterways must meet one or more of the following criteria:

- Worked in urban planning, local government, tourism, recreation or for waterways for at least 3 years
- Undertaken research in the area of urban planning, local government, tourism, recreation or waterways for at least 3 years
- Worked in settings where 'liveability' has been a primary consideration in Melbourne or cities with similar levels of development

And specific to ecology an expert must:

- hold a degree in ecology or cognate discipline or equivalent experience
- work or have worked in freshwater ecology or a related science for at least 3 years

Using these definitions recruitment for the Delphi commenced initially from within the steering committee. The panel of experts was progressively extended by approximately 20 people as a consequence of the final question in round one which asked participants to recommend other experts, even if they held opposing or different views.

The current Delphi study was conducted via a web-based survey that allowed an open response format and quantitative survey responses. Two groups of experts were employed in relation to amenity and ecology with each group responding to similarly framed questions over three separate rounds of enquiry. Participants were initially contacted by email with an outline of the study aims and approach, along with an online survey link to each round of the Delphi study. The first round of the study was open for four weeks, the second for five weeks and the final round for three weeks. To increase participation, two reminder emails were sent to participants prior to each deadline.

4.2 Application and Key Findings

4.2.1 Round One

In the initial round there were four open-ended questions. The initial question was asked in relation to the waterway system overall (question 1) and was framed as follows:

When you think of Melbourne's waterways overall, what are the things that contribute to its Ecological (Amenity) value.

The subsequent three questions were similarly framed and asked in relation to rivers (question 2), estuaries (question 3) and wetlands (question 4). Two final questions requested any additional information that may be relevant and also sought recommendations of other experts who might participate – even if they may hold opposing or different views on values. This final question sought to develop a diverse and broad panel. Participants were also given the option to 'opt out' of the study and to avoid further contact.

Specifically for the study of *amenity values*, of the 50 participants, 22 (44 %) responded to the first round of questions. Over 170 comments were generated in response to the four open-ended questions. These comments were grouped into 17 themes, using a triangulation approach. More specifically, the themes were developed independently by two of the researchers and consensus was reached by involving a third researcher. The 17 themes were then categorised into the hierarchy of 'drivers', 'components' and a single 'outcome' – in this case 'personal wellbeing'. Drivers were considered to be the tangible natural or physical characteristics of the waterways (e.g. infrastructure, plants) and components were higher order factors that were defined as the aesthetic and cognitive attributes that are beneficial (e.g. escape, appeal, recreation).

For the study of *ecological values*, 27 (34 %) participants responded to the first round of questions. A total of 91 comments were generated from the four open-ended questions, which were then grouped into five key themes. This followed a similar triangulation process described above. Again, themes were grouped into 'drivers' and 'components', however this

was in the context of a single outcome referred to as ‘ecological wellbeing’. In this case, drivers are antecedents that impact on components which are seen as more discrete markers of ecological well-being.

4.2.2 Round Two

Following round one, a second survey was developed and distributed to the amenity expert panel. Simultaneously, a second survey was distributed to the ecological expert panel. In this round, the study on amenity value generated a response from 20 participants, while the ecological survey generated 18 responses at this point.

In these surveys, the themes identified in round one were presented to the experts and participants were then asked to rate their importance from 1 (no importance) to 10 (extremely important). Subsequent questions gave respondents the opportunity to refine the labels of the themes or add to the existing ones. The final question asked participants if they had any further comments regarding the survey.

The 17 final themes and their general content for amenity value are shown in Table 1. The final five themes and an indicative description for ecological value are provided in Table 2 and 3.

4.2.3 Round Three

In round 3, the amenity survey had 21 participants and the ecological survey had 36 participants. In these surveys participants rated the drivers that were identified in round 2 in relation to each of the identified components.

Accordingly, in this Delphi process both qualitative and quantitative data analysis were used (see, for instance, Hsu and Sanford 2007). The common statistics used in Delphi studies are measures of central tendency (e.g. mean) and level of dispersion (e.g. standard deviation) in order to present information concerning the collective judgements of respondents (Hasson et al. 2000).

The mean scores and the standard deviations for the relationship between the amenity drivers and components are presented in Table 4. More specifically, respondents were asked to rate the impact that each of the drivers had on each of the indicators of amenity. As noted, these relationships were rated on their importance from (1) no importance to (10) extremely important. The questions were framed as follows:

“Now, we would like you to rate the impact that each of the DRIVERS has on each of the COMPONENTS of amenity. We have listed each DRIVER separately and ask that you rate the impact of each DRIVER on each of the COMPONENTS.

For example, if the DRIVER Animals has an extremely important impact on the COMPONENT Connection to Nature you might select '10' in the following question. Equally you might indicate that a particular DRIVER has no impact at all (i.e. tick a 0) on a particular COMPONENT.”

In this case, the driver with the highest average score is ‘Access’ with a mean of 7.9. Therefore, the collective judgement of the amenity experts advocates that access (i.e. both visual and physical access) to a waterway and its surrounding vegetation is the most important driver relative to the impact that it has on the components. In addition, the driver and

Table 1 Amenity value – drivers, components and outcome

Drivers	Components	Outcome
<ul style="list-style-type: none"> •Water-related Animals (e.g. fish, birds, platypus, frogs) •Water-related Plants (e.g. riparian corridor, native vegetation) •Water-related Infrastructure (e.g. seats, paths, board walks, label or educational signage, facilities) •Cleanliness of the waterways (e.g. odour, litter, colour, turbidity, erosion) •Cleanliness of the surrounding landscape (e.g. odour, litter, colour, turbidity, erosion) •Access (i.e. both visual and physical access) to a waterway and its surrounding vegetation •Water-related Naturalness (e.g. natural components of the landscape, the geology, natural light, water level) 	<ul style="list-style-type: none"> •Connection to Nature that Melbourne waterways provide for people •Indirect Values (e.g. the retention and protection of vegetation, knowing it is there to be enjoyed) •Escape (e.g. experience of isolation, escape, feeling of refuge) •Water-related Aesthetic Appeal (e.g. views, scent, bird noises, sound of the water, the relative impact of noise pollution, regulation of temperature) •Water-related Cultural Significance (e.g. meaning for people, heritage place, memories) •Social Interaction (e.g. communing with another, socialising) •Social Benefits (e.g. education, tourism, economy) •Ability to engage in active recreation in or on the waterway (e.g. swimming, boating) •Ability to engage in active recreation in proximity to the waterway (e.g. walk, cycle, run) •Ability to engage in passive recreation in proximity to the waterway (e.g. sit, picnic, reflect) 	<ul style="list-style-type: none"> •Personal Wellbeing (e.g. recharge, relaxation, tranquil place, health benefits, exercise)

component relationships that have a mean score greater than 9 are highlighted in Table 4. This indicates that the experts collectively regard these particular drivers as having a strong and important impact on the corresponding component. Obviously, having some understanding of the relative importance of drivers and components enables us to better predict the consequences of specific management interventions. Put differently, these data indicate the critical role of access in driving amenity outcomes, in the context of urban waterways.

The mean scores and standard deviations for the relationship between the ecological drivers and components are presented in Table 5. As was the case with the amenity survey, respondents were asked to rate the impact that each of the drivers had on each of the indicators of ecological value. These relationships were also rated on their importance from (1) no importance to (10) extremely important. The questions were framed as follows:

“Now, we would like you to rate the impact that each of the DRIVERS has on each of the COMPONENTS of the ecological value of waterways. We have listed each DRIVER separately and ask that you rate the impact of each DRIVER on each of the COMPONENTS.

For example, if the DRIVER Water Quality has an extremely important impact on the COMPONENT Plants you might select '10' in the following question. Equally you might indicate that a particular DRIVER has no impact at all (i.e. tick a 0) on a particular INDICATOR.”

Table 2 Ecological values – drivers

Drivers	Description (Indicative only)
Water quality	<ul style="list-style-type: none"> •nutrient loads (nitrogen, phosphorus, potassium), herbicides, pesticides •sulphidic sediments •salinity levels •temperature •pollution, e.g. toxins, metals, nanoparticles, <i>E. coli</i> (faecal contamination) •concentrations of oxygen (dissolved) •pH •algae (excessive) •turbidity, clear water, suspended matter in the water column, brackish •litter load, ballast water discharge and other waste
Hydrological Regime	<ul style="list-style-type: none"> •flow regimes --slackwater/blackwater, pools, flooding (temporary will connect waterways), sediment loads (erosion, movement/delivery, deposition) •water availability -- volume, timing, magnitude, velocity, depth and frequency of flows •unregulated systems tend to have higher values because hydrological regime ensures maintenance of ecological processes including temperature cues for fish spawning and plant seed production and recruitment •groundwater input to stream flow (although source not always obvious) •watering regimes (esp. wetlands) -- flooding, wetting/drying cycles (magnitude, frequency, timing and duration), permanent inundation or permanent drying, flow detention times, seasonal changes and variability, depth profile (ephemeral, shallow and deep water zones), variability •flushing (esp. estuaries) -- tidal exchange, tidal fluxes, salinity gradients, fresh-water inflows •water sources •(laterally, longitudinally, vertically) between tributaries, rivers, floodplains, associated wetlands, estuaries, open to the sea, estuarine wetlands, estuarine mudflats, but also wildlife corridors, native vegetation remnants, between freshwater and marine habitats •timing, length, frequency, periodicity, seasonality of opening/closing •ensures dispersal of aquatic fauna and plant propagules, opportunities for aquatic fauna (especially fish) to access nursery and spawning habitat •barriers (weirs, dams, poorly designed culverts etc.) reduce connectivity

In this case, the driver with the highest average score is ‘Hydrological Regime’, where the mean score is 8.83. Here, the collective judgement of the ecological experts supports hydrological regime as the most important driver relative to the impact that it has on the components (see Table 2 for a description of hydrological regime). Moreover, the driver and component relationships that have a mean score greater than 9 are highlighted in Table 5. This indicates that the experts collectively regard these particular drivers as having a strong and important impact on the corresponding component. Thus, the critical importance of the hydrological regime in supporting higher ecological values is highlighted by these data.

The drivers of amenity and ecological value identified in the Delphi analysis act as a novel and sound foundation for making transparent actions that relate to amenity and ecological value of waterways. More specifically, the study has revealed drivers that can be mapped to existing standards and guidelines to ensure the amenity and ecological characteristics of waterways can be meaningfully described. For example, the ‘hydrological regime’ and ‘water quality’ drivers of ecological value can be described in terms of the Victorian Index of Stream Condition (ISC), which was briefly outlined in section 1.0. Accordingly, waterways can be given a hydrological regime and water quality score that provides a meaningful way to

Table 3 Ecological values – components

Components	Description (Indicative only)
Animals (presence and diversity)	<ul style="list-style-type: none"> •macroinvertebrates •native aquatic animal species (birds, fish, crustaceans, frogs, turtles, platypus etc) •number and diversity of species •composition and structure sympathetic to context •specific threatened animal species (e.g. Yarra pygmy perch, Macquarie perch, Australian grayling etc) •pest species, exotic biota
Plants (presence and diversity)	<ul style="list-style-type: none"> •number and diversity of species •cover and density •macrophytes (e.g. reeds) •vegetation for amenity, micro-climate and habitat services •composition and structure sympathetic to context •location -- fringing, in-stream, cover, catchment, intertidal, mangroves, seagrass •remnant (native plants), agricultural and exotic, pests and weeds •seed banks
Physical structure	<ul style="list-style-type: none"> •substrate diversity (natural mud or gravel) or human-built (channel modification e.g. levees, pipes, concrete straightening), barrages/weirs •deepening, artificially opening intermittently closed (esp. estuaries) •morphologic diversity (sediments, hydraulic habitat etc.) •physical structure that provides living space, refugia and nursery environments for juveniles •structural complexity in and out of the water -- large woody debris/snags, coarse particulate organic material (CPOM) •undercut banks, stable banks, degraded river banks •pool size and depth variability, channelization, incision

measure these particular drivers. Similarly, the drivers of amenity value can also be mapped onto existing standards and guidelines. For instance, the ‘access’ driver can be described in terms of whether a waterway meets the strategies and guidelines developed by Melbourne Water Corporation as best management practices for Melbourne’s waterways. For example, do particular waterways meet: (a) Melbourne Water’s Shared Pathways Guidelines (includes bridges and crossings) and (b) Melbourne Water’s Signage Guidelines. Accordingly, the extent to which ‘access’ to waterways exists can be meaningfully measured. Table 6 lists each of the drivers identified for amenity and ecological values and outlines how these are linked to the standards and guidelines relevant to the driver.

Ultimately, the drivers identified in the Delphi study provide a means to accurately describe the components of waterways and can also form the basis for additional measurement tools such as non-market valuation. For instance, utilities in Australia have increasingly used non-market valuation studies to gauge customer’s willingness to pay for specific interventions. Clearly articulating the link between actions and outcomes can substantially improve the accuracy of these measures. This issue is explained in more detail in the following section.

5 Implications for Efficient Regulation and Service Provision

In the previous section we illustrated how expert knowledge could be systematically employed to provide transparent links between activities by waterway managers and outcomes. However,

Table 4 Amenity value – Mean score of the importance of the relationship between drivers and components (with standard deviation in parentheses)

COMPONENTS	DRIVERS Mean (Standard Deviation)						
	Water-related Animals	Water-related Plants	Water-related Infrastructure	Cleanliness of the waterways	Cleanliness of the surrounding landscape	Access to a waterway and surrounding vegetation	Water-related Naturalness
Connection to Nature that Melbourne waterways provide for people	8.33 (1.91)	9.19 (0.74)	6.86 (2.85)	8.52 (1.16)	8.71 (1.27)	8.43 (1.28)	8.76 (1.17)
Indirect Values (e.g. the retention and protection of vegetation, knowing it is there to be enjoyed)	7.19 (2.25)	8.71 (1.45)	4.81 (3.07)	7.14 (2.71)	6.76 (3.06)	6.19 (2.44)	8.33 (1.98)
Escape (e.g. experience of isolation, escape, feeling of refuge)	6.05 (1.93)	8.62 (1.46)	5.52 (2.42)	7.90 (1.70)	8.28 (1.42)	7.57 (1.59)	8.28 (1.67)
Water-related Aesthetic Appeal (e.g. views, scent, bird noises, sound of the water, the relative impact of noise pollution, regulation of temperature)	7.57 (2.06)	8.67 (1.19)	5.71 (2.68)	8.76 (1.04)	8.52 (1.28)	7.57 (1.66)	8.52 (1.24)
Water-related Cultural Significance (e.g. meaning for people, heritage place, memories)	6.67 (2.52)	7.14 (1.85)	5.33 (2.26)	6.76 (1.86)	6.57 (1.83)	6.09 (2.44)	7.00 (2.75)
Social Interaction (e.g. communing with another, socialising)	5.00 (2.14)	6.90 (1.81)	8.33 (1.49)	7.38 (1.43)	8.00 (1.09)	8.19 (1.28)	5.90 (1.89)
Social Benefits (e.g. education, tourism, economy)	7.24 (1.61)	7.10 (1.92)	8.38 (1.49)	7.66 (1.62)	7.76 (1.78)	7.95 (1.53)	6.90 (1.48)
Ability to engage in active recreation in or on the waterway (e.g. swimming, boating)	4.14 (2.88)	5.14 (2.66)	8.29 (1.90)	9.09 (1.14)	7.14 (2.3)	8.85 (1.59)	6.04 (2.26)
Ability to engage in active recreation in proximity to the waterway (e.g. walk, cycle, run)	3.95 (2.45)	5.81 (2.71)	9.14 (1.11)	6.85 (1.98)	7.66 (1.85)	9.04 (0.97)	5.9 (2.41)
Ability to engage in passive recreation in proximity to the waterway (e.g. sit, picnic, reflect)	5.29 (2.88)	6.95 (2.80)	8.71 (1.42)	7.57 (1.83)	8.38 (1.63)	9.19 (0.87)	6.85 (2.08)
Total Average	6.142857143	7.42381	7.109524	7.766667	7.780952	7.909524	7.257143

to make use of this information to improve economic efficiency, mechanisms are needed that translate management choices into costs and benefits.

The basic tenet of cost-reflective pricing is that water and the services that relate to it should be used only up to the point where benefits equate costs. The theoretical elegance of this approach is that water is then deployed efficiently, in the economic sense at least.

However, there remains a major gap in this method as not all benefits that attend water are clearly visible in markets; for example, there is no market for the environmental or amenity benefits from improved management of urban waterways. Some benefits can be easily inferred from risk assessment and market data, like flood mitigation, but others are far more complex and often overlooked or aggregated. Against that background there is a risk that environmental and amenity benefits from these streams will be under-supplied because agencies responsible for waterway management, like Melbourne Water, are constrained to deliver only those services for which there is a measurable demand. Set against this is the possibility of over-supply of such services where potential beneficiaries, frustrated by the absence of a clear measure of environmental and amenity benefits, mobilise political forces that result in over-provision.

Table 5 Ecological Value – Mean score of the importance of the relationship between Drivers and Components (with standard deviation in parentheses)

COMPONENTS	DRIVERS Mean (Standard Deviation)	
	Water Quality	Hydrological Regime
Water-related Plants	7.50 (1.99)	8.63 (1.55)
Water-related Animals	9.22 (0.89)	8.88 (1.32)
Physical Structure	3.75 (2.78)	8.97 (1.00)
Total Average	6.82	8.83

Economists have spent the last 50 years developing and refining techniques that can reasonably measure demand where there is no market. When carefully used, such techniques have the potential to limit under-provision and/or over-provision of a range of non-market goods (Rolfe et al. 2000). These techniques fall into two broad categories: market-related measures and stated preference approaches. The former uses existing markets to act as a proxy for demand for the underlying environmental good (e.g. Tapsuwan et al. 2012), but such approaches are notoriously data intensive and, in any case, do not capture all benefits. In contrast, the stated preference approaches ‘create’ a hypothetical market and then use survey data to enumerate a generalizable value for environmental change. There are several stated preference approaches but a technique known as Choice Modelling has been widely recommended for many water-related applications (e.g. Cooper et al. 2011). Choice Modelling ‘creates’ a market for goods with each comprising different attributes. Respondents are asked to compare goods and choose one over the other. The attributes used to describe each good must include a price but other relevant features, such as indicators of ecological health, accessibility for recreation or features that might add to other elements of amenity could be included. By repeating the choice experiment with different levels and across a sample of the population it is then possible to statistically identify how different segments of the community trade off price against other attributes. This becomes the basis on which willingness to pay, or demand, can be estimated.

Whilst major advances have been made in many areas of Choice Modelling, an ongoing challenge relates to the description of complex attributes in a form that is accessible for those participating in choice experiments. As a general rule, practitioners of Choice Modelling seek to generate attributes that: (1) can be traced back to policy or management options, (2) are grounded in at least some scientific information, and (3) are also sufficiently simple to encourage a high response rate from the general population. In the context of water quality, attributes are thus commonly described by suitability for use - potable, swimmable, suitable for boating (see, Rolfe and Windle 2011) - albeit with limited direct reference to water chemistry

Table 6 Drivers mapped onto standards or guidelines

Drivers	Standards and guidelines
Water-related Animals	<ol style="list-style-type: none"> 1. The extent to which there are water-related animals using the waterways as their habitat or passing through them without harm. 2. The extent to which the water-related animals are native species of significance as listed under the Flora and Fauna Guarantee Act and Environmental Protection and Biodiversity Conservation Act. 3. The extent the waterway does not obstruct water-related animals (e.g. fish birds, platypus, frogs) and meets the strategies and guidelines developed as best management practices in Victoria's catchments. For example, do the waterways meet: <ul style="list-style-type: none"> •The Department of Sustainability and Environment's Guidelines for Waterway Management for 'Fish Passage Through Culverts' section 3.3.19. •The design requirements for the safe passage of platypus (see Serena and Williams 2008). •Melbourne Water's guidelines for birds and bird roosting sites.
Water-related Plants	<ol style="list-style-type: none"> 1. The extent to which the water-related plants are native species of significance as listed on the Ecological Vegetation Classes (EVC). 2. The extent to which the waterway harms water-related plants, both native and introduced (e.g. shrubs, grasses and trees) and is consistent with the strategic direction of Victoria's Native Vegetation Management: A Framework for Action.
Water-related Infrastructure	<ol style="list-style-type: none"> 1. The extent to which the infrastructure (e.g. paths, board walks, label or educational signage) surrounding these waterways does not obstruct the native environment – is the primary purpose of this infrastructure is to create access to nature? 2. The extent to which the infrastructure surrounding these waterways meets the strategies and guidelines developed as best management practices for Melbourne's waterways. For example, do the waterways meet: <ul style="list-style-type: none"> •Melbourne Water's Shared Pathways Guidelines (includes bridges and crossings) •Melbourne Water's Signage Guidelines
Cleanliness of waterways	<ol style="list-style-type: none"> 1. The extent to which the waterways are clean in terms of odour, litter, colour, turbidity, and erosion. 2. The extent to which the cleanliness of the water meets the Australian and New Zealand guidelines for fresh marine water quality 3. The extent to which the maintenance of the waterways meets the maintenance checklist of Melbourne Water's Constructed Wetlands Guidelines, where inspection is carried out every 3 months. For example, the waterways are inspected and maintained in terms of: <ul style="list-style-type: none"> •Evidence of odours •litter accumulation •evidence of damage or vandalism •evidence of dumping •condition of the aquatic vegetation (disease, pest infection, dead plants)
Cleanliness of surrounding landscape	<ol style="list-style-type: none"> 1. The extent to which the surrounding landscape of these waterways is clean in terms of odour, litter, colour, and erosion. 2. The extent to which the maintenance of these waterways meets the maintenance checklist of Melbourne Water's Constructed Wetlands Guidelines, where inspection is carried out every 3 months. For example, the waterways are inspected and maintained in terms of: <ul style="list-style-type: none"> •Evidence of odours •litter accumulation •evidence of damage or vandalism •evidence of dumping •condition of the aquatic vegetation (disease, pest infection, dead plants)

Table 6 (continued)

Drivers	Standards and guidelines
Access	<ol style="list-style-type: none"> 1. The extent to which there is easy physical and visual access to these waterways and the surrounding vegetation. 2. The extent to which the means of access meets the guidelines developed as best management practice of Melbourne's waterways. For example, these waterways meet: <ul style="list-style-type: none"> •Melbourne Water's Shared Pathways Guidelines (includes bridges and crossings) •Melbourne Water's Access for Maintenance guidelines
Naturalness	<ol style="list-style-type: none"> 1. The extent to which these waterways take 'natural-form' and resemble natural components of the landscape. 2. The extent to which the form, roughness, and pools and riffles of the waterway meet Melbourne Water's Constructed Waterways in Urban Developments Guidelines. 3. The extent to which the form of these waterways meet the Australian Rainfall and Runoff guidelines, section 1.7 and 1.8 and Melbourne Water's Land Development Manual.
Water quality	<ol style="list-style-type: none"> 1. The extent to which these waterways meet the Australian and New Zealand guidelines for fresh marine water quality 2. The Victorian Index of Stream Condition (ISC) is a tool used to categorise the ecological health of our waterways. The ISC is made up of five sub-indices: hydrology, streamside zone, physical form, water quality and aquatic life. Each river reach assessed is given an overall ISC score of between 0 and 50. This score is then categorised into one of five broad condition bands – excellent (>70 %), good (51–70 %), moderate (31–50 %), poor (11–30 %) or very poor (<10 %). What is the water quality score of the waterway.
Hydrological Regime	<ol style="list-style-type: none"> 1. The Victorian Index of Stream Condition (ISC) is a tool used to categorise the ecological health of our waterways. The ISC is made up of five sub-indices: hydrology, streamside zone, physical form, water quality and aquatic life. Each river reach assessed is given an overall ISC score of between 0 and 50. This score is then categorised into one of five broad condition bands – excellent (>70 %), good (51–70 %), moderate (31–50 %), poor (11–30 %) or very poor (<10 %). What is the hydrological regime score of the waterway.

or related disciplines. In the case of something as complex as the ecological health of waterways, attributes have been described in terms of the number of species that are protected or the length of waterway that is of a particular standard (e.g. Kragt and Bennett 2011). Arguably, these measures act as proxies that illustrate community preferences, albeit within the limited information sets provided to respondents.

Perhaps not surprisingly, Choice Modelling is not without its critics, in part because of the necessity to simplify important scientific information in order to generate responses from the general population (Hanley et al. 2001). In the context of urban waterways in particular, the measurement challenge for practitioners of Choice Modelling is exacerbated by the suite of 'other' psychological relationships between well-functioning urban waterways and human well-being, or amenity.

In this regard, we use the term 'amenity' to describe the genre of so-called 'non-ecological' benefits, although the literature is somewhat divided on this point. For example, in the lexicon

of the ecosystem services approach amenity forms a subset of cultural values (Costanza et al. 1997) but amenity is also seen as separate and yet overlapping with tourism, recreation and non-use values (MacDonald et al. 2011). We noted earlier that in the case of urban waterway management, the term ‘amenity’ is frequently used by water agencies as a catch-all for human values that are not directly associated with ecological characteristics. Völker and Kistemann (2011, p. 458) conclude that “urban environments, although the everyday environment for most of us and therefore important for any goals towards health promotion are underrepresented in current literature on blue therapeutic landscapes” and “there is little respect for water and health in urban planning issues”.

It is our contention that the method and results presented in Section 4 specifically address these challenges. Having systematically identified the relationship between the drivers and components of ecological and human wellbeing we are able to plan and compare alternative actions that relate to waterway management. Importantly, this also provides much greater confidence around the application of non-market techniques which are commonly used to assign values to management options.

6 Concluding Remarks

Waterway management is complicated by the requirement to integrate multiple values, including ecological and amenity values. This is becoming increasingly challenging in urban contexts and where increasing incomes require greater attention to environmental and amenity values. Set against the challenges of IWRM is the need to simultaneously align benefits and costs of various waterway users in order to fulfil economic efficiency criteria.

Without decomposing the factors that underpin ecological and amenity value it is not possible to systematically analyse the actions of waterway managers. This stands to undermine efforts to apply IWRM, since the links between management choices and multiple benefits are not clear. In addition, the absence of this information makes it difficult to describe the benefits that accrue and thus compare these against costs.

Efficient strategies that aim to maximise the benefits of waterways within a given budget require an understanding of the costs and benefits of investment decisions. Accordingly, it is imperative that we are able to trace how amenity and ecological benefits of waterways are generated. The results presented in this paper provide that information, at least in the context of Melbourne, Australia.

The results of this Delphi study also provide a sound foundation for informing the initial stages required for non-market valuation studies in this context. From a regulatory perspective, quantifying the benefits of urban waterways is of particular value. More specifically, the regulatory environment that shapes the operating environments of Melbourne Water Corporation requires that benefits be measured, where practicable, to guard against over or under investment. From a technical perspective, this study has improved the methodological developments in the measurement of non-market goods generally, and more specifically for the concepts ecological value and amenity value associated with Melbourne’s waterways.

The Delphi results also provide additional insight into somewhat vague concepts such as liveability. The Victorian Competition and Efficiency Commission sought to offer a global definition of liveability in 2008 and argued that the concept reflected “the wellbeing of a community and compris[ed] the many characteristics that make a location a place where

people want to live now and in the future”. Melbourne Water subsequently announced that integrated management of waterways was a central component of the city’s liveability. The Delphi has improved our understanding of the linkages between the management of urban waterways, human well-being and liveability.

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